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THE RED SPIDER OF CITRUS TREES

BY
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THE RED SPIDER

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THE RED SPIDER OF CITRUS TREES.

The investigation of the red-spider on the citrus trees of southern California was undertaken in response to a very urgent request of the Horticultural Commissioners of Los Angeles County, and has been conducted in coöperation with them. A large part of the work was under the immediate charge of Mr. W. H. Volck, a student in the Entomological Department, who was appointed as inspector by the Los Angeles County Board for this purpose. The present bulletin is only a report of progress, since the investigation is still under way and some of the most important facts remain yet to be determined. The season is nearly here for the red spider to resume its injury, and this is published in order to place in the hands of the orange growers the information already accumulated, so that they may make use of it during the present season.

Red spiders have been injurious in southern California for many years, but little attention has been given to the matter, chiefly on account of the extremely minute size of these creatures. During the past shipping season the injury to the fruit caused by the improper use of distillate sprays, awakened more than usual interest in the subject of spotted fruit, including that produced by other agencies. The theory was advanced, and generally believed by the growers, that the red spider was accountable for one of the commoner forms of spotting very prevalent during the past season. The results of the studies made this summer on its habits have thrown great doubt, if not indeed disproved the possibility of this mite producing anything like this kind of injury. There is no doubt that its work, however, has resulted in considerable losses to the growers of oranges and lemons that have not been clearly recognized.

The injuries produced by the red spider are chiefly of two sorts, both dependent upon a diminution of the general health of the tree. The one most readily recognized is the unusual or excessive dropping of the fruit from the trees badly affected. Usually this dropping is not to be attributed to the work of the mite alone, but other things contribute to the result. The other form of injury still more difficult to estimate is the loss which results from the decrease in the size and sugar content of the fruit, that cannot help but occur when the leaves

are injured in the way that results from the feeding of this mite. To these may be added the effects that may occur in a diminution of the growth of the tree; but it is possible that the dropping of the fruit may relieve the tree and counterbalance, in part at least, the direct injury.

The appearance of the fruit from trees badly infested with the red spider is very characteristic, and easily recognized when once known, but has not, as far as we can learn, been taken into consideration in the grading of fruit. Should the market come to recognize and begin to discriminate against the paler fruit, upon which the mite has been at work, the losses would become very large.

The Species Concerned.—The red spider that attacks citrus trees in southern California is an entirely different creature from that, known by the same name, that occurs, all over the State, upon deciduous trees, particularly the stone fruits. The species also differs from the one most prevalent on citrus trees in Florida, and from the greenhouse pest which in this State often attacks ornamental plants quite seriously. These latter species belong to the same genus as the mite on our orange trees, and are therefore quite closely allied. Many other mites do injury in California and some of them attack citrus trees. The best known of these is the silver mite, so troublesome in San Diego County, which belongs to an entirely different group than do the red spiders, and is capable of producing a much greater direct loss to the grower than any other mite which attacks these fruits in this State.

The red spider with which we have to deal was first described by Hubbard in his report on the orange insects of Florida. Curiously enough, Hubbard supposed it to be carnivorous, but Banks, in Bulletin 8 of the technical Series of the Division of Entomology U. S. Department of Agriculture, in monographing the members of this group, states that Hubbard must have been mistaken, since all the other members of the genus are vegetable feeders. Our species, *Tetranychus mytilaspidis*, differs in a number of respects from most of the other members of the genus, particularly in the presence of conspicuous tubercules upon which the large spines are borne. The only other species possessing these tubercules and known to occur in the United States, has not as yet been reported from this State.

Life History.

The Egg.—The eggs of the red spider are very peculiar in the possession of a long slender stalk projecting from the middle of the top side, extending upward nearly twice as high again as the egg itself. Not including the stalk, the egg is perhaps a third wider than high, and circular in outline as seen from above. The stalk is transparent and

surmounted on the top by a very slightly enlarged transverse section, to which is attached, immediately after laying, a series of rather regularly arranged delicate silken threads, about fourteen in number, radiating from this point to the surface of the leaf, forming a series of guys by which the egg is held firmly in position in spite of the fact that otherwise it is very loosely attached to the leaf. These are shown in Fig. 1. The egg-sucking *Coniopteryx* described in the latter part of this bulletin, very commonly pushes the egg loose from its attachment at the base, in its efforts to puncture it, but does not succeed in pushing it off from the plant on account of the strength of the guys.

The egg when first laid is uniformly bright red in color. Very soon one may observe a very curious series of changes taking place in the substance of the egg, showing the progress of the development of the young creature within. The length of time necessary to develop and hatch varies more or less with the temperature, being distinctly more rapid in summer than in winter, but also varies a great deal when all the conditions are the same. Of two eggs laid the same day by the same parent, and lying adjacent to each other on the same leaf, one will sometimes require nearly twice the time as the other before the young mite appears. In general, the time may be given for the majority of the eggs as between one and two weeks.

The egg shell breaks open to allow the exit of the young mite in a very regular manner. This break occurs all the way around the egg at the equatorial line. The top half is held in position by the guys previously described, so that when the shell is empty the two halves may retain almost their same relative position.

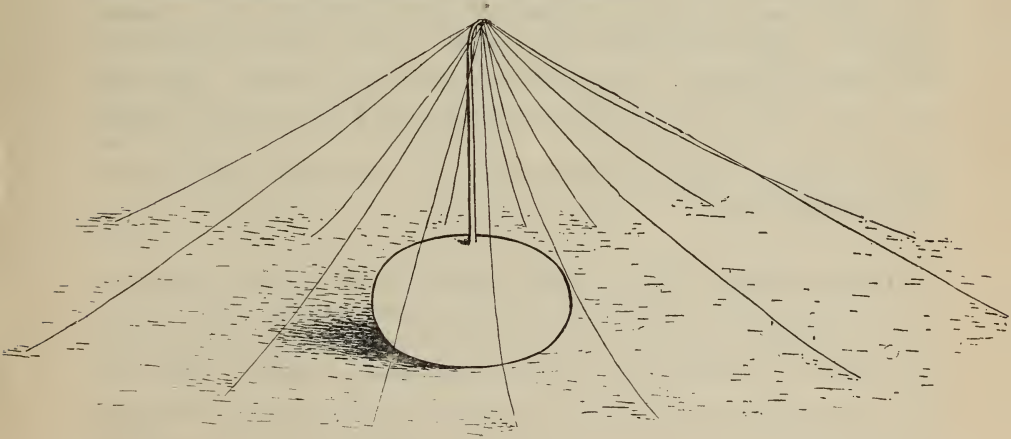

FIG. 1.

THE EGG OF THE RED SPIDER SHOWING THE STALK AND SILKEN GUYS.

The Young Mite.—Upon hatching, the creature which appears resembles the adult mite very closely except in size and in the absence of the hind pair of legs, making the number six, thus resembling insects to this extent. Many other mites are six-legged when first hatched from the egg.

The young red spider at once begins to feed and is very soon ready to prepare for the change of skin which results in the assumption of the fourth pair of legs. About a day's feeding will furnish sufficient growth for this change. The old skin is not changed at once, but the mite goes into a resting condition which requires nearly as much time as does the feeding period. Mites when in their resting condition place themselves in a very characteristic attitude. The position of the feet is similar to that assumed when feeding, which is shown in the figures of the adult spider, but the mouth-parts are retracted. The color of the whole anterior end of the body is changed, becoming much paler or entirely white, the red coloring being withdrawn entirely from this region. The legs are pulled partly back into the body, so that one can see the feet, which are being remodeled, lying within the skin about to be discarded and appearing as one leg within another. At this time, in a specimen that has been cleared by soaking in alcohol and especially if it is also stained, one can also very plainly see the newly forming fourth pair of legs. These lie doubled up against the ventral side of the abdomen just behind the third pair.

After about a day of rest, during which the new skin is formed, the back of the old skin splits and the first eight-legged stage appears. This eight-legged mite is scarcely larger than the newly hatched one, and would not be easily distinguished but for the number of legs it possesses. The feeding and rest periods in this stage cover three or four days, and there is a very material growth to be noted. When the mite enters upon its second rest-period, preparatory to a second moult, it has become about half grown. The history of the third stage of the mite is almost an exact repetition of that of the second, only that the mite is much larger.

Feeding Habits.—The mouth parts of the red spider consist of an oval plate projecting forward above and between the front legs, bearing on the underside a sharp sword-shaped vertical blade, on each side of which there is a rather fleshy palpus and a slender lancet. When the mite has selected a location and is about to begin to feed, it bends the mandibular plate down towards the leaf, pulling the whole organ at the same time into the body and bringing the point of the median blade against the surface of the leaf. The blade is guided and held

in place by the palpi. The mite now forces the mouth parts forward, effectively slitting the tissue of the leaf with the blade. Before performing this last operation it has carefully placed the two anterior pairs of legs directly in front of the body in the position shown in the figures so that they will hold to the best advantage as an anchorage while the surface of the leaf is being broken. The strain is so hard that the feet will often slip during the process.

After the slit is made the blade seems to be withdrawn and the lancets inserted, the palpi serving to direct them; these lancets can be thrust out and retracted by means of muscles attached directly to their bases. The juices of the leaf are sucked up through a tube-like cavity between the palpi; and where each slit is made and the contents pumped out a paler spot remains. Each spot is almost microscopic in size, but the combined work of many mites on a leaf produces an injury that is very evident. On the leaf the color of the spot is a dull, pale green, which as the leaf turns yellowish becomes quite undistinguishable from other parts of the leaf. On the fruit of the orange the appearance while it remains green is the same as on the leaf. As the fruit ripens the spots do not become invisible but are pale yellow, contrasting even more clearly than before with the normal color of the fruit. Spots made by the mite on the ripe orange are the same in color as those made while the fruit was green.

The young red spider feeds almost continuously, except at the rest periods preceding each change of skin. It does not stay at any one spot any great length of time, but after pumping one place dry will walk a short distance and then take another meal. The time when the mite wanders most is just after the last moult, which usually occurs on an older leaf. The male may remain on these leaves, but the female generally proceeds to young foliage that has grown during the period the mite was coming to maturity. In this way the newer foliage will seem to have only adult females.

The Adult Male.—The male is very much smaller than the female, though possessing legs of about equal length. It is extremely active, wandering about, particularly on the older leaves where the young insects are most abundant, feeding from time to time, but apparently spending the major portion of its life in moving. They are not to be found at all, apparently, on the more exposed leaves of the plant, but are fairly abundant on the under sides of the older leaves. The total numbers on the tree are probably about one-half as many as of the females. The male examines and seems to work over the resting stages of the young insect with its palpi very persistently, and will often

remain for a long time perfectly quiescent beside one of these young individuals. Indeed the most ready means of recognizing the male is by searching for pairs of individuals standing side by side.

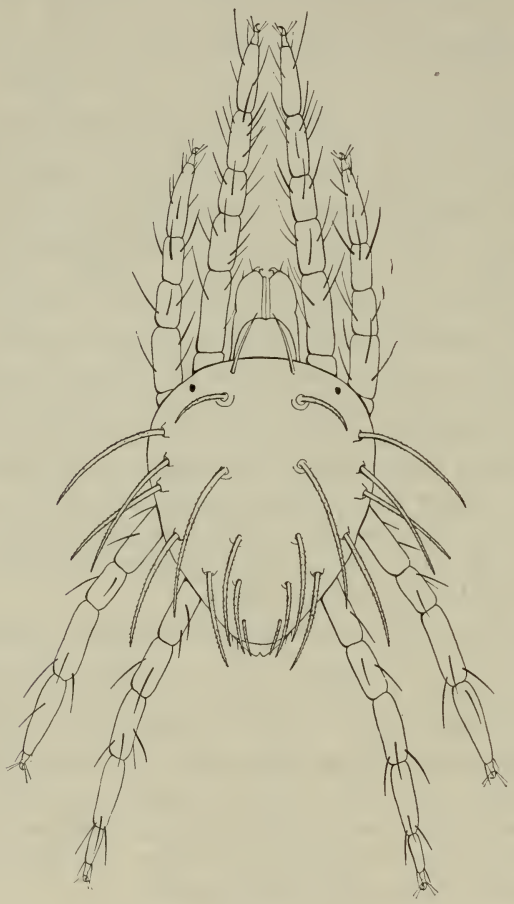

FIG. 2.
THE MALE RED SPIDER.

The Adult Female.—The appearance of the adult female is well shown in Figure 3 and in the frontispiece. It is on this insect that the hairs will be seen to be best developed. The exact arrangement of the hairs can be made out by the comparison of the illustration. The hairs consist of two kinds—short ones upon the legs and a few at the extremities of the body, and large, curved bristle-like hairs upon the back. These latter are densely beset with fine projections, which have been supposed to afford points for condensation of moisture, keeping the body of the insect itself dry. The function of the hairs appears to

be largely that of protection against the creature's enemies. They are so placed that it is very difficult for an insect to reach the body of the mite with its jaws. The feeding habits of the adult are the same as described for the young insect.

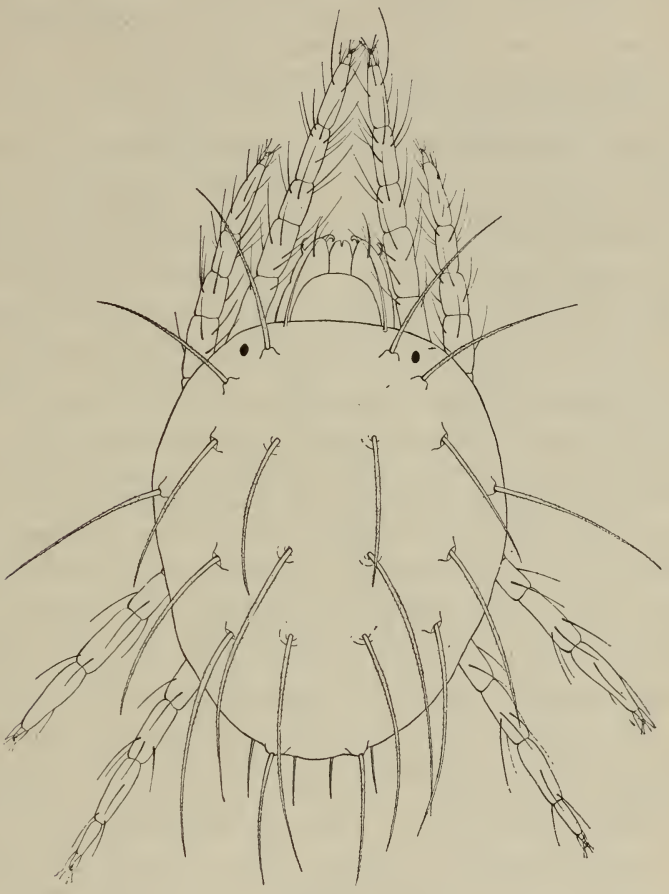

FIG. 3.

THE FEMALE RED SPIDER.

Egg-Laying.—The mite prefers a somewhat protected location for egg-laying. The place most commonly selected is on the leaf surface immediately adjacent to the midrib, especially on the underside. Very commonly also, eggs will be seen just beneath the edge of the leaf where the surface curls slightly downward. Another favored place for oviposition is the hollow on the under side where the membrane cups upward between two veins. Occasionally an egg will be laid in

an exposed situation; eggs are found to some extent upon the fruit, being situated almost always in the hollow.

The number of eggs produced by this insect depends to a large extent upon the length of life. We have repeatedly obtained as high as eighteen eggs from a single female in our breeding experiments, and eggs are produced as rapidly as three per day for considerable periods. It is impossible to say whether the mite is under the best conditions in our breeding cages, and whether more might not have been produced under perfectly normal conditions.

The egg is laid while the insect is actually feeding, and the process has several times been observed under the microscope. As soon as the egg is deposited upon the leaf, the insect, still keeping its mouth parts attached to the leaf, brings the hind legs partly under the body, lifting the latter high into the air. At the same time that the body is lifted the stem of the egg is emitted, and the mite rests for a moment with the body held in this elevated position. Then the mite ceases to feed, works the abdomen about a little at the top of the egg shell, apparently bringing the feet against the stem of the eggs and moves the body back and forth to and from the surface of the leaf. In this way the silken guys already referred to are spun and attached. The number of guys placed around the egg is considerably larger than the number of trips made by the abdomen from the top of the egg stem to the surface of the leaf, so that it is probable that the legs aid in the placing of these latter upon the leaf surface. We were not able to satisfy ourselves as to the exact position of the spinerets from which the silk is produced, but have very little doubt, from the process of egg laying observed, that they are situated near the hind end of the body. These silken strands are emitted by the insect at other times, as well as at egg laying, though not as abundantly as is the case with other species of red spiders. They often form quite a complete tent over a colony of young mites. The individual strands are so delicate that it is almost impossible to observe them. The mite is, in all probability, continually emitting silk as do true spiders, because when suddenly jarred from the leaf it will in most cases hang suspended in the air by a silken thread, which it uses to regain the leaf, in the same way that the true spiders climb the strands of their web.

Natural Enemies.

The experience of former years in reference to this mite is that it suddenly increases in the fall and decreases again in the spring, and may, at times, almost completely die out in an orchard and not appear again for several years. This suggested at once that the natural

enemies of these mites might be the most important factor in the problem. At the beginning of the investigation, therefore, a great deal of attention was given to the subject of the natural enemies of the red spider, and a large number of insects and mites were found to be engaged in feeding upon them. The most important of these we will discuss below.

Ladybirds.—The most conspicuous enemies of the red spider were the larvae of the ladybirds. The largest of these ladybirds was the common *Hippodamia convergens*, which was observed in all stages in the orchards about Azusa and indeed in every part of southern California visited. This insect lays its eggs in small masses of about a dozen eggs each almost anywhere, commonly on the orange leaves or even on the fence. The eggs are elongate, lying side by side attached by their ends. After hatching, the young larvae remain huddled over the egg shells for about a day, before they scatter and begin to feed. After scattering, each larva wanders about by itself, crawling over the leaves in search of food. It does not readily find a red spider, but apparently in an entirely accidental manner bumps against one while wandering about. After finding a red spider, however, it will, if hungry, at once pounce upon it and devour the whole mite in short order. If the larva is small or if it is not so hungry, it may merely eat out the larger part of the contents and leave the rest of the carcass upon the leaf. The young insects experience considerable difficulty in getting to the body of the mite between the hairs, but the older individuals seem strong enough to force the hairs out of the way. These ladybirds appear to prefer the orange plant louse which is also very abundant upon the orange trees during the winter season. After the ladybird larva is fully fed it proceeds to pupate upon the leaf, attaching itself by the hind end of the body in the manner usual with the ladybirds, the pupa being formed within the old larval skin, which splits open as soon as the pupa is complete. Emergence of the adult occurs in the same way by the long dorsal split. We have not observed the adult insect feeding upon the red spider, but have noted it eating the plant lice.

Another ladybird, a *Rhizobiid*, was more or less abundant in places, and the larva was repeatedly observed feeding upon the red spider. It appears, indeed, that the red spider constituted the bulk of the food of this creature, both in the larva and adult condition. These lady-birds were much less numerous than the former species and the egg stage was not observed.

Lace-winged Flies.—The larvæ of the common lace-winged fly (*Chrysopa californica* Coq.?) were very much more voracious than the larvæ of the ladybirds. Had they been as abundant as the latter it is possible they would have had an appreciable effect upon the numbers of the red spider, but while they were abundant enough to be collected in numbers they could not be considered as having any noticeable effect upon the mite. The lace-winged flies could readily be observed in all stages at any time upon the orange trees. The eggs are laid singly or only a few together, usually on the upper side of the leaf. The adult insect first exudes a long thread attached vertically to the surface of the leaf, and then deposits the egg upon the end of this stalk. The young insect that hatches can be readily distinguished from all other larvæ found on the orange leaves, by the large size of the jaws. The body is somewhat spindle-shaped, the legs are well developed and the insect is very active, devouring mite after mite in rapid succession. The insect does not eat up the mite it attacks, but merely sucks out the contents of the body. When full grown the larva makes a slight cocoon and transforms into a pupa, from which very soon the adult lace-winged fly emerges.

The Coniopteryx.—Rather closely related to the lace-winged fly is an insect bearing the name of Coniopteryx. The members of this group are very rare insects, only a single rare species being heretofore known in the United States. Our species was observed in considerable numbers in the orchards about Azusa and appears to be more important than any other of the natural enemies of the red spider. It works wholly upon the egg of the mite. The coniopteryx is a small, white-winged insect, suggesting somewhat a large "white fly." The adult insect moves about in much the same way as the lace-winged fly, and while slightly more abundant was by no means a conspicuous object. One point in the life history has not yet been cleared up,—the egg laying habits not having been observed. The young insect is a beautiful mottled black and white larva with somewhat the same general shape as those of the lace-winged fly, but with a head having protuding eyes and terminating in a slender beak instead of large, spreading jaws. The legs are very much smaller, though the insect gets about quite rapidly. It uses the posterior end of the body to a large extent to supplement the legs, there being a sucker-like organ at the end of the abdomen. The larva is continually at work searching for the eggs of the red spider, which as soon as found it proceeds to puncture. The egg shell is quite resistent, so it requires the utmost effort of the insect to accomplish its purpose. As soon as the shell is broken the larva

begins to suck out the contents, apparently projecting into it a slender tongue-like organ from the end of the proboscis, by means of which it laps up the last trace of the coloring matter from the inside of the shell, leaving it as white as though the mite had emerged. The rate of feeding depends entirely upon the abundance of eggs. When placed upon an orange well stocked with eggs, and observed under the microscope, one insect was noticed to remove the contents from the red spider eggs at the rate of two per minute for ten minutes at one time.

When the Coniopteryx larva is full grown it proceeds to spin a double cocoon on the under side of the leaf, consisting of an outer flat layer about 6 mm. in diameter, under the center of which it makes a nearly spherical inner covering.

Predaceous Mites.—The red spider is attacked by three or four kinds of predaceous mites. One large red species was extremely active and devoured the female mites very voraceously. All of the mites are sucking animals, therefore the body of a red spider remains on the leaf, after the attack of these predaceous species, or falls to the ground. Predaceous mites were never common enough anywhere to become an important factor in the life of the red spider. Certainly none of the enemies of the latter, as observed in southern California, could accomplish anything towards checking the increase of this creature. The fact was notable that the orchards first to become freed from the red spider last spring were not the ones in which we found the predatory forms most abundant. Under the conditions existing they constituted no appreciable factor in the decrease of numbers that occurred in the latter part of May, and in June.

Diseases.—In the orchards where the rapid decrease of the red spider was first observed, the presence of a fungus on dead mites was noted and collections were made in other orchards in order to determine its presence there. While the fungus was noted almost everywhere, still it was by no means so prevalent where the mites had not yet begun to die so rapidly. After the mites had almost disappeared from an orchard the remains of the red spider could be collected quite abundantly by beating the branches over a glazed paper tray, and their mummies almost invariably showed the presence of the fruiting threads of the fungus, extending out from the body. The full account of this fungus will be reserved for the final report on the red spider. The presumptive evidence that we have here a fungous disease seemed quite strong. Death was certainly not brought about by the condition of the weather directly, for in two orchards close together one may be badly infested and the other almost freed from the mite at the same time. We were

not able to produce the disease at will, however, either in the orchard or in our breeding cages; and the fungus is not one supposed to produce insect diseases, but belongs to a group ordinarily found on decaying substances. It would seem that if the death of the red spiders had been caused by any infectious disease, our experiments should have given more definite results. Further experiments with this possible disease of the red spider were of necessity deferred until another appearance of this mite gives opportunity. The definite relation of the red spider to the season of the year indicates that if there is a disease that is accountable for the diminution in the spring, it is one very dependent on weather conditions.

Remedies for the Red Spider.

The red spider of the citrus trees is so dependent upon the proper external conditions that it would seem that the most promising line of investigation would be to determine what the cause of death is at the time of their sudden decline in number, in the hope that one might artificially bring about those conditions. Much of our work has been directed toward that object, but the results have as yet been chiefly the elimination of the possibility of the natural enemies being any large factor in the problem. The approaching season of rapid increase may throw a good deal of light on the subject. For the present at least we must depend on the use of insecticides.

Fumigation.

The effectiveness of *cyanide fumigation* against most kinds of insects might lead one to expect that it would prove useful in combating the red spider. Hydrocyanic acid will destroy the mite if used in large enough doses and for a long enough time. It appears to be decidedly more resistant than the scale insects, however. Now, for the destruction of the latter, the practice is to use about as much as the tree will stand without serious injury to the foliage; but this strength is not sufficient to do satisfactory work in the killing of the red spider. It is the uniform experience of those who have observed the effects of the gas when fumigating trees infested with red spiders, that the latter are not appreciably diminished in numbers by the treatment. What is still more curious, fumigated trees appear to be more favorable to the red spider than are adjacent untreated trees, and are commonly more injured by the mite during the months immediately following the fumigation. The experience seems to be extensive enough to warrant the statement that *fumigation is of no value whatever as a means of controlling the red spider.*

Sulfuring.

The common red spider of deciduous trees has been quite satisfactorily controlled by the persistent use of sulfur. The practice is to dust the trees with the dry powder, applying it at the rate of about twenty-five pounds to the acre at each application. The method varies from throwing the sulfur into the trees by the hand, to the use of the seed sower or a rotary bellows geared to the wheel of a heavy farm wagon. The application is repeated whenever there is evidence of the beginning of a new attack, which may be several times in a single season. The action of the chemical is supposed to be the same as its action on mildew, for which it is used in the same way,—that is, the vapor produced by the heat is fatal to them. The effectiveness of this treatment depends, therefore, upon the occurrence of hot days. The species for which it is used does its worst work in the hottest part of the season. Where the summers never get hot, as at Berkeley, the red spider of the deciduous trees never does any serious injury though it is able to live, and appears to be always present. The red spider of the citrus trees requires some degree of dryness for its best development; this is usually not great near the coast, but still it is not able to do much during the hotter part of the year. Sulfur cannot therefore be expected to be as reliable against this mite, because of this difference in season. We know of no experiments on a scale large enough to fairly test the matter, but smaller experiments have given entirely negative results. It is probable that a few warm days in mid-winter would make sulfuring quite efficient, but as warm weather cannot be depended upon, sulfuring can at best be considered simply as a supplementary measure, useful only under favorable conditions.

Spraying.

As matters now stand the only really effective method of treating the red spider is the use of an insecticide applied as a spray. There are several substances that will kill it quite readily, at least in its active condition, and it is possible to prevent its injury almost entirely by this means. To do the best work it has been found necessary to make two or three applications, and it is therefore quite expensive. In the case of injury to a tree produced in the way this creature works, it is very difficult to make more than a rough guess as to the amount of loss occasioned, and therefore of the amount it is profitable to expend for the control of the pest. It is certain that where there is no scarcity of water and the orchard receives the proper attention, the mite is not likely to materially decrease the

growth of the tree. How completely the injury to the crop can be mitigated by giving the trees some extra care remains to be determined. Probably under most conditions the killing of the spider would result in a saving, far more than enough to pay for the number of sprayings necessary.

Citrus trees are extremely difficult to spray effectively. To do really effective work every leaf of the tree, as nearly as possible, should be thoroughly wetted on both sides. The web made by these mites, and their habit of chosing protected points for their transformation and egg-laying, requires that the spray should be applied with good force. The way the leaves are arranged on an orange tree makes it almost impossible to spray the tree thoroughly from the outside. The red spiders are wholly on the foliage, so that one does not have the same problem as when attempting to spray for scale insects; but the problem is none the less difficult.

The difference between thorough and careless spraying is very little in time or material but amounts to a great deal in efficiency. One should clearly appreciate all the difficulties and work intelligently and with a well thought-out plan.

Method of Spraying.—The following plan of operation is thought to provide for quite thorough work, more thorough than any of the methods now in use. The essential feature is the provision for as careful *inside* spraying work as is the practice on the outside of the tree. Many at present recognize the importance of inside spraying, and have adopted the practice of inserting the extension rod into the tree at several points for this purpose. It is possible for this method to result in a thorough treatment of the inside, but one cannot be sure. It is something like spraying the tree in the dark. The practice here proposed is to actually enter a tree and see what one is doing. It will be most convenient to spray the interior first, and for this a hose and nozzle without extension rod will be necessary. One man may confine his attention to the interior, and the other to the outside. The plan to be followed for inside spraying is shown in figure 4. The sprayer forces his way in between the branches to the center of the tree and begins to spray at, say, his left side, spraying thoroughly from the ground up to a line somewhat above the level of his head. The dotted line in the figure indicates approximately the course of the nozzle as he sprays the far side of the tree working around among the branches. The coures of the nozzle on the near side of the tree is indicated by the solid lines. After the lower part of the tree is thus thoroughly sprayed the upper part may be treated as indicated, the operator of the nozzle

finally backing out while doing the portion that stands directly over his head.

FIG. 4.

PLAN FOR INSIDE SPRAYING.

The object of spraying the lower part of the tree first is that in this way the sprayer will not be troubled by dripping from the leaves above him and will be more likely to do careful work.

The *outside* procedure is represented in figure 5. The letters *a*, *b*, and *c* indicate successive positions during the process. The extension rod is furnished with a nozzle giving an oblique discharge. The first attention is given to the top, which is the most difficult. The operator moves about the tree swinging his rod from *d* to *e* or from *f* to *g* until he is sure that everything is thoroughly wetted. He is then ready to begin on the lower part of the tree. The rod is now swung from the position *h* to *i*, back and forth, as he goes around the tree wetting everything in his progress.

The above plan is not expected to require any more material or time than spraying would ordinarily require if done without a definite plan, but should certainly be much more likely to wet every leaf with the spraying material.

Spraying Materials.—Only two substances have been used for spraying for the red spider. One of these, *distillate emulsion*, has apparently accomplished good results but is still in the experimental stage. We have given considerable attention to the subject, but have

not yet arrived at results that will enable us to make definite recommendations. There is no question of the killing power of the substance, but the effect on the tree is the matter that requires more attention. The product is not uniform, but could be if we had any definite idea of exactly what we want, as the refining companies are anxious to produce an article that will be satisfactory. We have obtained many samples of crude oils and distillates and have done considerable work in testing them, and have obtained some important results. These will be reserved for another bulletin.

FIG. 5.

PLAN FOR OUTSIDE SPRAYING.

A material that is both safe and effective is the *sulfid of potash spray mixture*. This mixture is usually made according to the following formula:

Potash	32 lbs.
Sulfur, finely ground	37 lbs.
Salt	2 lbs.
Water	50 gal.

This makes the stock-solution which is diluted with about a hundred times as much water for spraying. The potash, sulphur, and salt may be mixed together in a large metal tub with a little water,

when chemical action will at once set in and the whole mass will dissolve and begin to boil very vigorously. After the boiling has ceased, the water is added and the stock-solution is made. It is very doubtful whether the salt is of any value in this mixture, but it can at least do no harm as it is in such small quantity.

This sulfid of potash is of very little value, at least at this strength, as an insecticide, but is effective enough against the active stages of the mite. In order to kill the eggs and moulting forms it will be necessary to make three applications, separated by intervals of one week. This will make a very clean sweep.

Summary.

The red spider of citrus trees, *Tetranychus mytilaspidis*, does not produce the spotting of the fruit usually credited to it, but does cause dropping, and also injures the leaves. The eggs, which are very peculiar, may be found abundantly on the leaves and to some extent on the fruit. They hatch after a week or two, disclosing a six-legged mite, which after about two days, one of which is spent in feeding, changes its skin and becomes eight-legged. Two more moults occur, requiring five or six days each before the adult mite appears. It feeds on the leaf by making a slit, out of which it sucks the contents of the cells beneath. The male is very active and is found mostly on the older leaves. The female is much larger than the male, and lays a great many eggs.

The natural enemies most abundant are the ladybirds, the lacewing flies, the coniopteryx and a number of species of mites. They do not accomplish much toward the checking of the red spider. A fungus was studied that may be the direct cause of the spring decrease of the mite, but the weather is the really important item.

Until we learn more about the reasons of the natural decrease of the red spider we will have to depend on the use of insecticides. Fumigation is of no value for this purpose. Sulphur is not as valuable as it is for the red spider of deciduous trees. Spraying is a difficult operation on dense trees like the orange, and is done best by spraying both from the inside and the outside. Distillates may prove to be the best material, but until we know better how to avoid injury to the tree, sulfid of potash is to be recommended.